International Journal of Agricultural Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 6, Issue 2, Apr 2016, 313-320

ASSESSMENT OF NITROGEN RELEASE CHARACTERISTICS OF FERTILIZER PELLET OF NUTRISEED PACK AND STANDARDIZATION FOR SUPPORTING TOMATO CROP

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ABSTRACT

Nutriseed Pack is a tubular assembly composed of fertilizer pellet and manure pellet for placing in the root zone soil of seedling at the time of transplanting. Laboratory experiment was conducted to record the amount of nutrients released through polymer coated paper of fertilizer pellet pack with paper wrap and gel additives. Urea/ Diammonium phosphate (DAP) as sources of N, single superphosphate (SSP)/ DAP as sources of P, and muriate of potash (MOP) as source of K were used as fertilizer source along with 4 combinations (maida, sago granule, corn flour and no gel) of gel additives and single and double layers of polymer coated paper to enhance the slow release characteristic. Sixteen treatments were formulated combining the fertilizer source, gel, news print paper wrap and layers of polymer coated papers. However, in this paper only N release has been discussed. During the period of 12 weeks, highest available N estimated in soil, placed with fertilizer pellet pack having Single layer (214.2 mg) and Single layer +Wrap + Maida (209.4 mg). Available N release was highest without additive (107.5 mg) followed by Maida (93.6 mg), Corn flour (84.1 mg) and sago (49.9 mg). Although the release was highest in Single layer + No additive, the release pattern was steep and irregular while the release pattern of Single layer +Wrap + Maida was regular and steady the entire incubation period. So this treatment was standardized for tomato crop.

KEYWORDS: Nutriseed Pack, Fertilizer Pellet, Gel Additive, Nitrogen Release

Received: Feb 24, 2016; **Accepted:** Mar 19, 2016; **Published:** Mar 31, 2016; **Paper Id.:** IJASRAPR201643

Original Article

INTRODUCTION

Tomato ***(****Lycopersicon esculentum)* is an important vegetable crop belonging to the family *Solanaceae* and one of the most important 'protective foods' because of its special nutritive value. For tomato production soil fertility management is crucial for getting maximum yield. For maintaining continual soil productivity, the ratio of nutrient uptake to inputs should be carefully balanced. Continuous supply of macronutrients, mainly nitrogen, phosphorous and potassium and micronutrients are required for tomato production in order to stimulate root development, crop growth, yield and quality. Due to the injudicious and imbalanced use of inorganic fertilizers often good yield is not achieved at harvest (Arya and Roy, 2011). High nutrient use efficiency is not achieved due to surface broadcast of fertilizers. Alternatively root zone deep placement with slow release principle by Nutriseed Pack placement is highly beneficial as it maintain adequate level of nutrients and provide favorable conditions for achieving high yield of tomato and nutrient use efficiency. Bautista *et al.* (2000) concluded that placement of any N material with simultaneous soil cover was effective in minimizing floodwater ammonium-N losses and ammonia volatilization. Deivanai (2005) experimented with Nutriseed holder which contained seed on top cavity

manure in the middle tube and fertilizer at bottom cavity, which gave 42-58 per cent increase in ADT 36 rice yield grown in soil column, when compared to surface broadcast method, under submerged water regime. Peter *et al.* (2002) found that incorporated or surface band-applied N produced considerably greater yields compared with broadcasted N. Tewari *et al.* (2004) found that the deep placement of slow release fertilizer kept nodule dry weight higher. Upendra Singh *et al*. (2008) reported that the deep-point placement of N, P and K briquettes significantly increased grain and straw yields. Nutriseed Pack Technique has been recently developed in the Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore. Nutriseed Pack consists of seed at top, manure pellet at middle and fertilizer pellet at bottom. In present study the incubation experiment for assessing nutrient release from the fertilizer pellet of Nutriseed Pack was carried out before implementation in the field for standardization of suitable fertilizer pellet pack combination for tomato growth.

MATERIALS AND METHODS

A laboratory experiment was conducted to estimate the amount of nitrogen released from encapsulated Fertilizer Pellet Pack (FPP) at weekly intervals. The soil for this laboratory incubation study was brought from field No. 36 of Eastern block farm, TNAU, Coimbatore. The soil was a member of fine montmorillonitic isohyperthermic *Vertic Ustropept* classified under sandy clay loam of Periyanaickenpalayam soil series.

Pellet Composition and Method of Incubation

The composition of fertilizer pellet was worked out according to the recommended dose of tomato crop. The recommended dose of each primary nutrient (200-250-250 kg $N\text{-}P_2O_5\text{-}K_2O$ ha^{-1}) for tomato was divided by the plant population per hectare and per plant requirement was found out. Fertilizers as Urea, DAP, SSP and MOP were mixed in a ratio as per treatment. The gel additives were added at 1 per cent of fertilizer mixture. Then the mixture was pelleted in to 15g pellets. These pellets were then encapsulated in the polymer coated paper. It was placed inside a transparent plastic tumbler (150 ml capacity) containing 100g soil. A hole of 5 mm diameter was provided at bottom of the tumbler to drain out excess water by gravity. While placing the Fertilizer Pellet Pack first 50 g dry soil was added to the tumbler, then the pellet was positioned and then remaining 50 g soil was added. Water was added (about 50 ml) to saturate the soil. Then the assembly was kept inside a large 200 ml plastic container having 1 cm of water at the bottom. Then the container was closed by screw lid. The treatments were replicated twice. Sixteen treatments were formulated combining fertilizer pellets, gels, newsprint paper wrap and polymer coated paper layers. The treatment detail has been given in Table 1.

Table 1: Treatment Details of Fertilizer Pellet Pack (FPP) in Incubation Experiment

T. No	Treatment	Details
T_1	FPP (Single layer)	with single polymer layer
T_2	FPP (Single layer) + Wrap	T_1 + Pellet wrapped in Paper
T_3	FPP (Double layer)	with double polymer layer
T_4	FPP (Double layer) + Wrap	T_3 + Pellet wrapped in Paper
T_5	FPP (Single layer) + Maida	T_1 + Maida flour in fertilizer
T_6	FPP (Single layer) + Wrap + Maida	T_2 + Maida flour in fertilizer
T_7	FPP (Double layer) + Maida	T_3 + Maida flour in fertilizer
T_8	FPP (Double layer) + Wrap + Maida	T_4 + Maida flour in fertilizer
T_9	FPP (Single layer) + Corn flour	T_1 + Corn flour in fertilizer
T_{10}	FPP (Single layer) + Wrap + Corn flour	T_2 + Corn flour in fertilizer
T_{11}	FPP (Double layer) + Corn flour	T_3 + Corn flour in fertilizer

Table 1: Contd.,		
T_{12}	FPP (Double layer) + Wrap + Corn flour	T_4 + Corn flour in fertilizer
T_{13}	FPP (Single layer) + Sago	T_1 + Sago granule in fertilizer
T_{14}	FPP (Single layer) + Wrap + Sago	T_2 + Sago granule in fertilizer
T_{15}	FPP (Double layer) + Sago	T_3 + Sago granule in fertilizer
T_{16}	FPP (Double layer) + Wrap + Sago	T_4 + Sago granule in fertilizer

FPP – Fertilizer Pellet Pack

Analysis of Incubated Soil

At every period of sampling the wet soil incubated inside the tumbler was carefully poured out in to a clean plastic tray. Carefully the remains of fertilizer pellet pack was removed out without any tear or damage. Then the wet soil was homogenized with a spatula. From the homogenized wet soil sub samples were taken different analyses.

Estimation of N

30 g wet soil was distilled by adding 100 ml of 0.32% $KMnO_4$ and 100 ml of 2.5 per cent NaOH as per Subbiah and Asija (1956) method, and the ammonia released was trapped in 2 per cent boric acid and titrated against 0.02 N in early periods or 0.2 N H_2SO_4 in later periods as per the magnitude of ammonia released.

Estimation of Moisture

Appropriate sub sample was taken from wet soil and moisture was estimated gravimetrically.

Period of Estimation and Expression of Results

Analysis of soil sample was done at weekly intervals up to 12 weeks after placement of Fertilizer Pellet Pack. By soil moisture adjustment, the results of soil nutrient analysis were expressed on dry weight basis.

RESULTS AND DISCUSSIONS

In the incubated soil the release of N estimated in terms of available N was expressed in mg per container or per 100g soil. Among the treatments, the available N (Table 2) varied from 4 mg in fertilizer pellet pack with Double layer + Sago (T_{15}) on 2nd Week After Incubation (WAI) to 482.9 mg in Single layer + Wrap + Maida (T_6) on 12th WAI. Within weeks of incubation periods, available N ranged from 7.0 mg in 1st to 173.7 mg in 12th WAI.

Within the treatments, the highest available N (214 mg) was observed in Single layer (T_1) which was at par with Single layer + Wrap + Maida (T_6) recording 209 mg. Low release was observed ranging from 27 mg for Double Layer + Maida (T_7) to 14 mg for Double Layer + Wrap (T_3). Among all the treatments high, irregular and steep release was found in pack with single layer and no additive (T_1) showing increasing release up to 10th WAI (434 mg) followed by stable release up to 12th WAI (261 mg). Moderate and smooth release was noted with pack having Single layer + Wrap + Maida additive (T_6) showing smoothly increasing release almost linearly from 1st (6 mg) to 12th WAI (483 mg). Slow and small release was noticed in pack with Double layer + Wrap + Sago granules (T_{16}) showing almost a constant release from 1st (9 mg) to 11th WAI (67 mg), after that sudden increase in release up to 12th WAI (14 mg).

Comparing the effect of different additives, the highest release was recorded for with no additive (108 mg) followed by Maida (94 mg) and corn (84 mg). The least release was recorded for sago additive (50 mg).

Among the treatments, pack with Single Layer + Wrap + Maida (T_6) recorded the steadiest release (209.4 mg) which may be considered optimum for the fast growing exhaustive crop like tomato. From the observation it was confirmed that the addition of gel has definite effect on reducing release of available N. Sago addition reduced the release to a great extent which may not be suitable for crop growth. Maida in combination with paper wrap increased the release and also the paper wrap showed a smoothening effect. The available N (Figure 1) at different weeks after incubation (WAI) significantly varied due to the treatment effect. The treatments with gel additives showed controlled release. The best release pattern was observed in case of Single layer + wrap + maida (T_6).

This effect can be attributed to the imbibing property of the newsprint paper wrap as it contains cellulose. Due to presence of cellulose it would have imbibed moisture uniformly which would have facilitated the uniform release.

Table 2: Nitrogen Released During Period Of Incubation (Mg Per 100g Soil)

T. No.	Weeks after Incubation (WAI)												Mean	Mean of Additives
	1	2	3	4	5	6	7	8	9	10	11	12		
T_1	17.3	7.7	156.2	185.7	229.6	324.4	300.2	327.2	185.0	434.1	355.0	260.9	214.2	107.5
T_2	6.2	7.5	132.8	138.6	136.5	102.4	237.5	253.2	233.3	299.2	406.8	356.0	177.8	
T_3	6.2	9.5	13.6	25.9	32.3	34.3	29.9	21.8	14.3	34.6	18.8	66.8	23.9	
T_4	5.3	7.8	14.1	13.8	15.1	17.6	26.7	10.7	11.2	18.0	7.5	31.8	14.1	
T_5	6.5	25.0	138.5	148.6	162.8	139.7	152.6	186.3	177.0	138.3	111.9	215.0	123.6	93.6
T_6	5.8	69.5	90.3	139.9	195.6	211.8	222.6	266.7	252.9	337.7	441.0	482.9	209.4	
T_7	6.0	11.2	14.7	21.4	25.8	21.8	48.6	17.7	7.2	10.5	48.7	106.7	26.7	
T_8	5.1	5.2	15.6	15.9	17.4	7.1	10.5	17.6	24.7	18.3	10.8	33.5	14.6	
T_9	5.8	7.1	16.4	84.2	131.3	40.0	90.9	369.4	289.5	318.1	415.4	424.5	169.4	84.1
T_{10}	8.5	6.9	12.4	47.3	77.8	123.8	84.4	112.8	221.6	250.4	380.9	405.3	134.0	
T_{11}	5.8	6.6	14.5	13.6	10.8	21.4	28.6	14.8	17.8	10.7	22.2	44.5	17.1	
T_{12}	7.8	5.4	14.4	17.6	18.1	13.7	25.1	17.3	25.3	14.0	17.8	17.8	15.9	
T_{13}	8.5	6.4	16.4	58.7	80.9	195.3	151.9	265.7	235.7	159.8	289.6	418.1	146.2	49.9
T_{14}	5.1	5.2	16.1	19.8	21.5	14.2	17.0	19.8	24.6	32.2	53.6	34.9	21.4	
T_{15}	9.0	4.0	17.4	18.6	17.5	17.3	39.1	14.7	14.4	14.4	18.4	28.1	17.5	
T_{16}	8.5	5.0	13.9	11.9	10.5	20.8	10.9	21.5	14.5	18.6	20.9	14.0	14.4	
Mean	7.0	11.3	41.2	56.8	69.9	77.2	87.3	114.4	103.4	124.6	154.7	173.7		
		T		P		T X P								
SEd		12.40		10.62		41.12								
CD		24.30**		20.81**		80.59*								

T_1	FPP (Single Layer -SL)	T_5	FPP (SL) + Maida	T_9	FPP (SL) + Corn flour	T_{13}	FPP (SL) + Sago
T_2	FPP (SL) + Wrap	T_6	FPP (SL) + Wrap + Maida	T_{10}	FPP (SL) + Wrap + Corn flour	T_{14}	FPP (SL) + Wrap + Sago
T_3	FPP (Double layer-DL)	T_7	FPP (DL) + Maida	T_{11}	FPP (DL) + Corn flour	T_{15}	FPP (DL) + Sago
T_4	FPP (DL) + Wrap	T_8	FPP (DL) + Wrap + Maida	T_{12}	FPP (DL) + Wrap + Corn flour	T_{16}	FPP (DL) + Wrap + Sago

The treatments with double layer of polymer coated paper showed erratic release without additive and with additive the release was controlled to greater extent and found irregular. This may be ascribed to the slow releasing property of the polymer coated paper itself. When the layers were doubled the release was reduced to the barest minimum.

The addition of another layer of paper wrap reduced irregular electrolyte release due to its moisture absorption, storage and surface spread capabilities, and thus showed a smoothening effect on release. When no additives or wrap were used, there were irregular increase and decrease was observed particularly for available N. The increase may be contributed to ammonia release from urea and DAP. Subsequent decrease might have resulted due to localized accumulation of ammonium compounds which might have inhibited microbial activity. Again in later stages may be with prolonged time, ammonium compounds might have dissolved in soil water and dissociated to give ammonium ions. With resultant reduced concentration of ammonium, nitrifying bacteria might have become active. Then nitrification would have been the cause of increase in later periods. For example, the percentage release (Table 3) was very low ranging from 0.31 per cent in fertilizer pellet pack with Double Layer + Sago (T_{15}) on 2nd WAI to 37.15 percent in Single Layer + Wrap + Maida (T_6) on 12th WAI. This might be due to absence of crop uptake. When there was no uptake in incubation, the N released to the soil solution would have been fixed as ammonium in soil and further lost by denitrification, which were not included in analysis. In soils with a high ammonium fixation capacity, at least a part of the NH_4^+ supplied as fertilizer may be bound in clay mineral interlayers (Tang *et al.* 2008). The share of added NH_4^+ fixed depends on the NH_4^+ fixation capacity of the soil (Scherer 1993). Kowalenko (1978) reported that 59 per cent of 152 kg N ha^{-1} added as $(NH_4)_2SO_4$ were fixed. In the case of NH_4^+ slow release fertilizers the process of NH_4^+ fixation may be prolonged and the share of fixed NH_4^+ is assumed to be even higher.

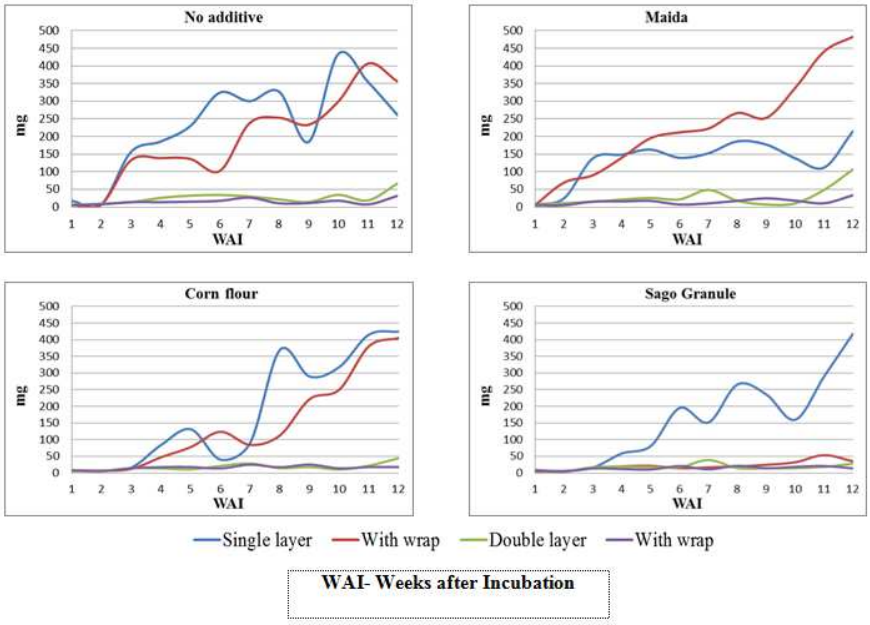

Figure 1: Release Pattern of Available Nitrogen during Period of Incubation

Table 3: Percentage Nitrogen Released During Period of Incubation (%)

T. No.	Weeks after Incubation (WAI)												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
T_1	1.33	0.59	12.01	14.28	17.66	24.96	23.09	25.17	14.23	33.39	27.31	20.07	16.47
T_2	0.48	0.57	10.22	10.66	10.50	7.88	18.27	19.48	17.95	23.01	31.29	27.39	13.68
T_3	0.48	0.73	1.04	1.99	2.48	2.64	2.30	1.68	1.10	2.66	1.45	5.14	1.84
T_4	0.41	0.60	1.09	1.06	1.16	1.35	2.05	0.82	0.86	1.38	0.57	2.45	1.09
T_5	0.50	1.92	10.65	11.43	12.52	10.75	11.74	14.33	13.62	10.64	8.61	16.54	9.51

Table 3: Contd.,													
T_6	0.45	5.34	6.95	10.76	15.05	16.29	17.12	20.52	19.46	25.98	33.92	37.15	16.11
T_7	0.46	0.86	1.13	1.65	1.98	1.68	3.74	1.36	0.55	0.81	3.75	8.21	2.06
T_8	0.39	0.40	1.20	1.22	1.34	0.55	0.80	1.35	1.90	1.41	0.83	2.58	1.12
T_9	0.45	0.55	1.26	6.48	10.10	3.08	6.99	28.41	22.27	24.47	31.96	32.66	13.03
T_{10}	0.65	0.53	0.95	3.64	5.99	9.52	6.50	8.67	17.05	19.26	29.30	31.18	10.31
T_{11}	0.45	0.51	1.11	1.05	0.83	1.64	2.20	1.14	1.37	0.83	1.71	3.42	1.32
T_{12}	0.60	0.42	1.11	1.35	1.39	1.05	1.93	1.33	1.95	1.07	1.37	1.37	1.22
T_{13}	0.65	0.50	1.26	4.52	6.22	15.02	11.69	20.44	18.13	12.29	22.28	32.16	11.24
T_{14}	0.39	0.40	1.24	1.52	1.66	1.09	1.31	1.52	1.89	2.48	4.12	2.68	1.65
T_{15}	0.69	0.31	1.34	1.43	1.35	1.33	3.01	1.13	1.11	1.11	1.42	2.16	1.35
T_{16}	0.65	0.38	1.07	0.92	0.80	1.60	0.84	1.65	1.12	1.43	1.61	1.07	1.11
Mean	0.54	0.87	3.17	4.37	5.38	5.93	6.71	8.80	7.96	9.59	11.90	13.36	
		T		P		T X P							
SEd		0.98		0.84		3.27							
CD		1.93**		1.65**		6.40*							

T_1	FPP (Single layer - SL)	T_5	FPP (SL) + Maida	T_9	FPP (SL) + Corn flour	T_{13}	FPP (SL) + Sago
T_2	FPP (SL) + Wrap	T_6	FPP (SL) + Wrap + Maida	T_{10}	FPP (SL) + Wrap + Corn flour	T_{14}	FPP (SL) + Wrap + Sago
T_3	FPP (Double layer-DL)	T_7	FPP (DL) + Maida	T_{11}	FPP (DL) + Corn flour	T_{15}	FPP (DL) + Sago
T_4	FPP (DL) + Wrap	T_8	FPP (DL) + Wrap + Maida	T_{12}	FPP (DL) + Wrap + Corn flour	T_{16}	FPP (DL) + Wrap + Sago

SUMMARY AND CONCLUSIONS

- Use of single layer of polymer coated paper was found very effective in imparting nutrient release behaviour.
- Before placing into polymer coated paper pack, when fertilizer pellet was wrapped with a layer of newsprint paper, then the release was best controlled as uniform, smooth and steady release. The recorded pattern of release with fertilizer + wrap indicated its suitability for placing it in the root zone of succulent and salinity sensitive crop of tomato.
- It was also found that providing double layer of polymer coated paper was not effective in releasing adequate amount of nutrients, and hence not suitable to tomato crop.
- Additives also play a role in the release of nutrients through the polycoat paper. The treatment with Maida additive was found to be controlling the release in optimum manner which is suitable for short duration crop like tomato.
- Addition of sago granules was not effective in boosting the release from the pack. There was also possibility to retard the release moderately by the addition of corn flour to fertilizer pellet.

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